Beyond the Coaches Eye: Understanding the 'How' and 'Why' of Maturity Selection Biases in Male Academy Soccer

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Abstract:

This study explored academy football coaches' perceptions and experiences of managing individual differences in the maturity timing of male adolescent football players in an English Premier League academy. Using a longitudinal mixed method design, 98 under 12-16 players were assessed for maturity status, growth velocities, and match performance grade. Interviews with nine respective coaches were conducted in parallel. The qualitative and quantitative data were combined to generate a contextualised richer understanding and four archetypal case studies. Findings showed coaches perceive various advantages and disadvantages to players maturing either ahead or in delay of their peers and had different expectations of performance based upon a players maturity status; biological maturity status and timing had large implications for selection and release decisions. This study highlights the challenges of developing, managing and selecting adolescent players in elite male youth football. Biological maturation confounds talent identification and development, and academy environments need to monitor maturity status and educate coaches and selectors on the complexities and intricacies of individual differences in maturity timing.

Keywords: Adolescence, Maturation, Soccer, Football, Talent

Introduction:

In sport, children are grouped by chronological age, however same age peers can differ by several years in skeletal age, an index of biological maturation[1,2] presenting significant challenge to those working with young athletes. Biological maturation is the process of progression towards the mature state and can be defined in terms of status, timing and tempo.[3] Status is the stage of maturity at the time of observation; whereas timing describes the age at which maturational events occur, e.g., puberty, menarche, peak height velocity (PHV).[2] Tempo refers to the rate at which maturation progresses.[4] Individual differences in maturation are determined by genetic and, to a lesser extent, environmental factors.[5,6]

Boys who mature early are taller and heavier from late childhood, experience PHV earlier, and gain greater pubertal gains in height, weight, lean mass and bone accretion.[2,4,7,8] Early maturing males are also stronger, faster, and more powerful than their late maturing peers.[2,4,9,10,11,12,13] Accordingly, maturity timing has important implications for talent identification, match performance and selection in youth sports.[3,4]

Timing of maturation and the growth spurt presents challenge in the evaluation of athletic ability and potential.[2,4,14,15,16,17] The athlete's physical and functional attributes also hold significant social stimulus value,[18] whereby athletes possessing the appropriate characteristics for success (i.e., early maturing boys) are offered more opportunities, coaching and resources.[4,19,20]

A maturity selection/exclusion gradient exists in many sports, including football, emerging at puberty and increasing with age and competitive level.[3,21,22] As a result of superior size and athleticism, early maturing boys are disproportionately overrepresented in academy football.[10,23,24,25,26] These advantages are, however, transient and generally diminished, and in some cases, reversed in adulthood.[27] Consequently, equally talented late maturing players may be overlooked or released too early. Although strategies to reduce maturity selection biases are being tested and trialled, e.g., bio-banding [4,28,29,30,31] the bias remains pervasive in academy football.[25,26,32]

Youth sport coaches are key stakeholders in the processes of talent identification and selection/retention decisions.[33,34] Growth and maturation has been shown to influence coaches' perceptions of ability/potential and performance, [4,15] with early maturing players perceived as more capable and better performers,[17] with greater potential.[35] It is, therefore, imperative to

understand coaches' perceptions of adolescent athletes pertaining to growth and maturation within academy talent identification systems.

Objective quantitative studies dominate the current literature; very few qualitative studies have been conducted exploring how changes associated with adolescence impact young athletes and their coaches' perceptions.[36] Exploratory qualitative research can explore 'how' and 'why' these maturation selection biases exist, and how it may be possible to mitigate and manage such biases. Therefore, the aim of this study was to understand youth football coaches' perceptions, experiences and management of male adolescent football players; how do coaches perceive and manage a group of athletes in varying stages of biological maturation/development, and what are the implications for selection, retention and release decisions.

Methodology:

Design:

A longitudinal mixed methods approach was applied to understand youth football coaches' perceptions, experiences, and management of male adolescent academy football players.[37] Over 12-months, quantitative and qualitative data were collected simultaneously in three phases (Jan-Apr, May-Sept, Oct-Jan). The data was combined to provide an in-depth understanding of coaches' perceptions and experiences. The players maturity status, growth velocity, match time and performance were measured and recorded every four months. Interviews with the coaches were conducted in parallel. The quantitative player data was used to supplement and provide context to the interview data, and not influence the discussion. Both approaches were combined to understand the complex phenomena of biological maturation in adolescence in a youth football context.[37]

Sample:

The sample involved male U12 to U16 players and their respective coaches from a Premier League Category One Academy.[38] Recruitment of these age-groups reflects the ages of experiencing puberty and maturation.[2] Due to the dynamic nature of academy football, the sample evolved throughout, with players joining and being released from the academy. The inclusion criteria, thus, specified males aged 11-16 years registered and attending the academy and their respective football coaches. Overall, nine male coaches and 98 boys were included (see supplementary Table 1). Coaches ranged in age from late twenties to early sixties, with

years of experience ranging from 8 to over 30 years. Of the nine coaches, three were qualified to UEFA-B licence, five held UEFA-A licence and one held UEFA-Pro licence.

Growth Velocities and Maturity Status:

Height and weight measurements enabled the calculation of growth velocities and estimation of biological maturity. Biological maturity was estimated using percentage of predicted adult height at time of observation (PPAH).[39] The estimate used the latest measure of the players age, height and weight and mid-height of biological parents.[2] Measurements were taken by the researcher and academy sports scientist at a standardised time for each phase of the study.

Game Performance:

Normal procedures within the academy involve the routine collection and recording of game time and performance, where each player receives a subjective performance grade for every game they participate in. This is assessed by their age-group coach and grades range from one to four. Grades represent whether players are below (1), approaching (2), meeting (3) or exceeding (4) the academy standard. Across the study period, game performance grades were collected and averaged for each phase of the study as well as the minutes they played over the same period (Jan-Apr, May-Sept, Oct-Jan).

Procedures: Qualitative Methodology:

Semi-structured interviews were used to obtain experiential accounts from youth football coaches about their experiences, perceptions, and management of adolescent players. Interviews were designed to explore the coach's general understanding and experiences and management of their specific players; for example, "how do you recognise differences in maturation status" and "what are the implications of differences in maturity status between players?". This allowed for coaches to talk more generally as well as discuss specific players in their age-group.

Overall, nine coaches were involved across the 12-month study, including two coaches for each age-group with one exception where only one coach was involved. While the aim was to conduct one-to-one interviews, scheduling demands meant that a number of age-group coaches requested to be interviewed together. As a result, the study is comprised of eight individual interviews and five group interviews. Interviews were conducted face to face ranging in time from 47 to 90 minutes and were recorded, transcribed by the primary researcher and subsequently analysed.

Inductive thematic analysis was used to identify, analyse, and report patterns and themes within the data, with initial coding led by the first author before being verified, thematised and categorised by the research team to aid rigour and trustworthiness.[40] Further to this, the thematic categories and key findings were subsequently discussed and validated with the academy coaches and sports science team. Case studies are presented for exploring the coach's experiences, perceptions, and management in different contexts, for individual players, utilising both the qualitative and quantitative data.[41]

Ethics:

Approval for this research was sought and granted from the University of Bath Research Ethics Approval Committee for Health (REACH, BATH, 2019). Additionally, the objectives, rationale and procedures of the study were explained to the Football Club for further approval.

Data Synthesis: Case Studies and Mixed Methods Approach:

The quantitative and qualitative data were collected simultaneously over a period of 12 months, combined to gain further understanding and context, then synthesised to culminate into four case studies.[37] Case study methodology is a comprehensive approach to describing and exploring complex issues where the researcher is interested in the phenomenon and the context in which it occurs.[41] The case studies used qualitative and quantitative data to illustrate the themes, about specific players perceived to be extreme or archetypal examples. These provide real lived examples of the complexities of working with adolescent athletes in a competitive talent environment.

Results and Discussion:

Across age-groups, coaches visually identified and categorised players at opposite ends of the maturity continuum as: "super early" (Coach 1) and "very late maturing" (Coach 3). Players perceived as maturing on-time were discussed less frequently. It should be noted that a significant proportion of players described as late maturing, were, in reality, on-time when compared to the general population, highlighting the extent to which advanced maturation is the norm in academy football.[22,25,26]

The following section presents four themes, with quotations, and four case studies, with further quotes presented as evidence in tables 1 to 3. The themes, (1) Early maturation, (2) Late maturation, (3) Differential Performance Expectations by Maturity Status, and (4) Implications for Selection, Retention and Release are presented below. Elements of the themes are illustrated within a series of four case studies, each of which represents a player archetype within the academy context. Further discussion of these case studies can be found in supplementary file 3.

1: Early Maturation

Coaches primarily identified early maturing players on the basis of size, physique, and athleticism. In addition to estimates of biological maturation (e.g., %PAH), coaches used facial features, muscle development, and comparisons to same age peers to distinguish maturity status. For many early maturing players, there was little worry over their future height and physicality: "I think he is going to be like 6ft1, and he has been this size since he was like 11 or 12 so it has been easy for him" (Coach 1). Early maturing players reach their adult height earlier [42] leading to less concern among coaches regarding future size.

Coaches described greater size and physicality as advantageous: "He manages to compete quite easily because he can use his body, he can protect the ball, he can move people" (Coach 1; player- growth velocity of 5.96cm/year, 92.9% PAH) (See Case Study One).

> *"Physically he has done quite well, I think he is one of the earlier maturing in the group and you can see that physically he is further ahead than some of the other players. How he has filled out and his physique and also like some of his facial features…another good indicator is his range of pass, the fact that he is physically capable to play the ball over a variety of different distances in comparison to others who maybe are later in the group" (Coach 6; player- growth velocity of 4.39 cm/year, 97% PAH, performance grade 2.63).*

Early maturing boys physically dominate play in competitive games.[22,23,28,43] They cover greater distances at high speed, reach higher peak speeds and participate in more high-intensity and repeated high-intensity actions.[13,44] Consistent with these findings, coaches perceived early maturing boys to use their physicality in training and competition to outperform their peers.

Players advanced in maturity were described as strong, physical, powerful players who added physicality and protection to the team.

> *"He is able to deal with the physicality, he is quite a big strong lad at the moment, and he deals with that physical side very well. And he adds that little bit of physicality to us as a group in that middle and central area" (Coach 3; player-growth velocity of 8.19cm/year, 95.6% PAH, performance grade 2.75).*

Coaches believed that early maturing players possessed the necessary size and physicality to command the game, offering protection to smaller and/or later maturing players. Previous research suggests that such attributes are especially valuable in central and defensive positions where size and physicality affords an advantage in physical contests.[10,22,45]

Early maturing players were also perceived to be more consistent and effective in their performances, giving the team the best chance to win: "…the lads that are early tend to have a greater effect on games" (Coach 5).

> *"...Tend to be more consistent performers... a range of things from ball retention, tied in with ball striking, coordination, to the athleticism to cover ground and compete, you know those types of things, they obviously, the Early's give you the best shot" (Coach 6).*

Post PHV status may explain the superiority and greater consistency in the performances of early maturing boys.[46] The importance of getting the growth spurt 'out of the way' has been alluded to in both sport and performance arts.[36,46] In addition to having reaped the benefits of pubertal change, post PHV boys are not required to adapt to the rapid changes in body size, physique and functionality.[46]

Early maturing players were perceived to increase a team's chances of success, due to their superior size, athleticism, and performance consistency; explaining why these individuals are overrepresented in football.[3,22,23,25,26,28]

Coaches also described disadvantages of earlier maturation, including limited potential for further growth or physical development:

> *"Early maturer, his muscle development…very strong and powerful, hasn't particularly grown and I am hoping he isn't done, I am hoping there a few more inches in him" (Coach 3- 94.6% PAH).*
>
> *"I think he is [biologically] 24, he probably reached his peak last year, and you can see now there is nothing else to come" (Coach 7)*
>
> *"I will hear people talk about him as an early maturer and so what else is there to come" (Coach 5).*

Young athletes experience their greatest fitness gains during puberty[2,9,47] with rates of improvement dissipating following PHV.[48] Unless these players are optimally engaged in strength and conditioning programmes, coaches may perceive post-PHV early maturing athletes as having peaked early; not improving as much as their later maturing peers. It is important for coaches to understand improvements continue into adulthood, albeit at a smaller rate, and so early maturing athletes are not 'done'.[48]

Coaches believed early maturing players relied upon their physicality in training and competition, neglecting their technical and tactical skills.

> *"I would say he gets away with a few things because of his size, I would like to see a neater first touch and more playing off two to improve his tempo, I think he takes extra touches because he can you know. We were doing 1v1, receiving to play forwards and he was just stepping on the ball and doing foot taps and holding the player away and I had to stop him and remind him what the objective of the task was" (Coach 4; player- 94.2% PAH, performance grade 2.75*).

Across the age-groups, coaches perceived many early maturing players to be technically and/or tactically deficient and expressed a need for those players to develop their skills and not solely rely on their physicality.

> *"Very early, physically really powerful, he is like a bull in a china shop… and that is how he identified himself as a player and how he is recognised, coaches have recognised that's what's good about him, he is a destroyer and like a wrecking ball. Technically he is behind, his understanding is behind" (Coach 1; player- growth velocity of 2.47cm/year, 88.6% PAH).*

Coaches described early maturing players as "predictable"; using their physicality to dominate, at the expense of learning and refining their technical and tactical skills. Coaches felt early maturing players experienced an easier journey through the academy than later maturing players (See Case Study One).

> *"Early mentality, which is you stop developing a lot of your game because you don't need to, your touch doesn't need to be perfect because you can bundle your way through, your movement doesn't need to be on-time because you are going to get there anyway, whereas (late maturing player) has to be spot on with everything or he knows he isn't going to survive" (Coach 5).*

The above quote highlights a challenge, whereby early maturing players fail to develop the technical and tactical elements necessary to succeed at the highest levels. Previous research shows some precocious players can display technical and tactical deficiencies due to over reliance on their physicality.[3,28,30] When early maturing players compete against those less mature, they experience less challenge, limiting their learning and development of psychological, technical, and tactical skills. [28,30]. This can be detrimental to an early maturing player's development and ultimate success [49] (See Case Study One). Importantly not all early maturing players are technically behind, and for those that are technically deficient, many still progress to the next level.[50]

Coaches described some early maturing players who did not use their advanced physicality to their advantage: "Although he has a physical presence in terms of his size, he doesn't use that at all" (Coach 3). Coaches often attributed this to players not needing to exert their physical strength, because of their advanced size, they would still be able to "get there":

"He can't really jump which is a problem for a goalkeeper, he just reaches which maybe he gets away with at the moment because he is one of the taller ones" (Coach 4).

Commonly, age-group coaches believed early maturing players were so advanced compared to some of their peers, that minimal physical effort was required for them to successfully compete. Not only does this hinder the athletes learning and development, but illustrates the competitive inequity often found in chronological age-groups.[4] Bio-banding, a strategy whereby players are grouped by maturity status, reduces extreme differences in maturity and size, creating more equitable challenges.[4]

Some coaches described a desire to push players advanced in maturation into older age-groups to promote their learning and development: "Look where they are physically and if they are early you are going to have to bump people up aren't you, to challenge them" (Coach 7). Playing early maturing players in older age-groups was recognised as a talent identification tool; "…future proofing him" (Coach 1) and as a player development tool: "We don't want him to end up as another early who overused his physical attributes and lost other attributes" (Coach 5) (See Case Study One).

Coaches also perceived early maturing athletes would be caught physically, but also overtaken in terms of technical and tactical understanding by later maturing boys.

> *"He is another one who I think has used his physicality, I think he has done, and I think it has made him look quite good as well, when he comes up against someone now who is a little bit nippy and sharp and speedy, he really struggles" (Coach 7; player- 98.4% PAH, performance grade 2.11).*

Coaches described early maturing players struggling when later maturing peers caught up to them: "An early who has got away with a lot in his early years and now there are people catching him and he is finding it more difficult" (Coach 6). The lack of challenge throughout the age-groups for early maturing athletes is problematic when the maturity-associated advantages in size and function are diminished in late adolescence and adulthood.[3,27] Consistent with these quotes, early maturing players are often 'found out' in the older age-groups, when their technical and/or tactical deficiencies show. This may explain why young players identified as talented fail to meet expectations in young adulthood.[3,27] Bio-banding encourages early maturing players to use/develop the technical and tactical element of their game by increasing the physical challenge.[28] Qualitative research has shown early maturing athletes found bio-banded games promoted a more technical and tactical style of game.[28] Research is warranted to explore whether strategies such as bio-banding reduce the number of early maturing players who are technically deficient.

[TABLE 1(EM) HERE]

[Case Study One here]

2: Late Maturation

Coaches perceived numerous advantages associated with later maturation. These players were identified as smaller and slighter: "…he is a later maturer within the group, just physically in general, smaller than everyone else" (Coach 6). Coaches recognised late maturing players would make gains in size and physicality and that physical testing scores should be evaluated by maturity status to account for maturational differences.

> *"Late maturing, testing for his age-group is just average, but biologically is good. Another really exciting prospect because when he physically develops, dad is a giant, dad is 6foot4, so he is going to be a good size, and he is going to be quite a complete package" (Coach 1; player-88.5% PAH, performance grade 2.87).*

The evaluations of athletes against maturity standards is good practice in talent identification and development. Cumming et al suggest combining maturity and fitness data to generate age and maturity specific fitness standards.[4] When comparing a late maturing player to their chronological age-group, their physical scores may appear to be poor; however, when judged relative to biological age, late maturing athletes' testing scores may appear more favourable.[4]

Late maturing players were described as 'exciting prospects', because they were perceived to be technically and tactically advanced.

> *"He has learned the tactics and the bigger picture, so he is just waiting for his body to catch up and when it does, I think he has got a massive amount of potential" (Coach 2).*

Late maturing players were highly developed in their technical and tactical skills to compensate for their lack of physicality. Coaches believed later maturing boys "…are forced to make better decisions" to remain within the system (Coach 5) (See Case Study Two).

Coaches described some attributes which late maturing players developed and adapted into their game to compensate for their lack of physicality. Anticipating and intercepting were examples of an adaption.

> *"…but I don't know whether it is by luck or he is quite bright but he has kind of adapted and adapted and found a way to compete, moving the ball quicker, taking less touches, picking out good spots, but in a 1v1 duel he will struggle" (Coach 1; player- growth velocity of 11.81cm/year, 89.5% PAH, performance grade 2.73).*

This is consistent with other research showing late maturing players display superior adaptive technical, tactical skills to their peers.[50,51,52] Late maturing boys must find ways to cope with their physical limitations in order to cope against the more mature players.[51,53] For some late maturing boys, their resilience and mentality to continually fight and adapt, means they overcome the challenges of their environment, and consequently go on to develop into professional athletes; Robert Eenhorn, a former National baseball coach described late maturing athletes as 'diamonds in the rough'.[54]

Although late maturing players may eventually rise to the top, they remain underrepresented in academy football.[3,22,25,26] Thus, any long term advantages only hold for the small number of late maturing athletes retained in academies.[25,26] Whether the small number of late maturing players in the system are selected because of their superior technical ability, which was necessary for them to be initially selected, or if they develop a superior ability due to the

challenging environment, warrants further investigation.[52] Zuber et al found that despite later maturing players possessing advanced technical and tactical skills, they still failed to progress to the next competitive level.[50] Thus, more research and strategies need to be investigated to reduce the under-representation of late maturing athletes in youth football.

Finally, coaches believed late maturing boys were particularly resilient. Some coaches described their late maturing players as underdogs who had to work harder: "He has definitely got the underdog theory, he is at people tackling them and running around, he is a real terrier" (Coach 2).

The above quotes align with the 'underdog' hypothesis, whereby relatively younger and/or later maturing players hold the best chance for success at the professional level.[3,52,55,56] Studies suggest for late maturing and relatively younger athletes to remain within competitive programmes and academies, they must possess or develop superior technical, tactical, and psychological skills.[52] As described previously, late maturing athletes experience a greater level of challenge which promotes and necessitates the development of many attributes.[52] For late maturing players to benefit from the 'underdog' principle they must, however, be retained within the system.[52] Youth sports programmes need to ensure they are not releasing and excluding late maturing players from the system and provide them the opportunity to progress to the next competitive level.

Coaches also described disadvantages associated with late maturation. Descriptors such as slight, small, and dot, were used to illustrate their lack of physicality: "Obviously there is a physical issue and we have spoken to him about being patient, slight lad" (Coach 3; player-growth velocity of 5.96cm/year, 91.5% PAH, performance grade 2.91). Coaches understood for many late maturing players, their growth spurt and the potential issues challenges were still to be experienced[46]: "At the moment he is doing well, his movement is good because he hasn't gone through a growth spurt yet, I think that helps" (Coach 3-87.4% PAH).

Although coaches understood the athlete's growth spurt and the possible detriments associated were still to occur for late maturing boys, this could be regarded positively. One advantage of developing late is the coordinative strength which can be developed before the growth spurt.[14] Balyi et al suggest late maturing athletes have an advantage over early maturing athletes due to the greater time spent in childhood i.e., 'learn to train' stage of Long Term Athlete Development (LTAD).[57] Nonetheless, late maturing athletes will experience PHV, albeit at a

smaller rate[58] and possible growth 'side-effects' in the older age-groups where intensity of training, competition and overall pressure is greater.[36]

Coaches questioned later maturing athletes' adult height; whether they will be big enough to succeed in their position: "…he is small and there are concerns about his predicted height" (Coach 3; player- growth velocity of 5.21cm/year, 86.2% PAH, performance grade 2.83). Coaches revealed doubt and uncertainty surrounding predictive height equations. Research shows predicted end height equations are reasonably accurate; The median error bound between actual and precited adult height using the Khamis-Roche method is 2.2cm in males from 4 to 17.5 years of age.[39] The use of self-reported parental heights in this equation, however, potentially decreases the accuracy of the estimation.[3] To further increase the accuracy and reliability of the method, boy's parents could also be measured where logistically possible.

Coaches appeared to have greater doubt over later maturing athletes reaching their predicted adult height. Academy practitioners should understand late maturing athletes will reach their final adult height, yet much later than their early maturing peers; thus, patience and understanding are required. Johnson advocates for using this end height prediction to better develop athletes in many sports.[59] The adult height of a young football player can be used to allocate individuals to the position best suited for success, instead of waiting until they are mature to find out they are too small for a position, leading to deselection or dropout.[59] Going forward, academies could better use these estimates of final adult size to provide the best opportunity and development for all players.

Coaches believed later maturing players struggled with the physical nature of the game. Later maturing boys struggled to cover the ground, had a smaller range of pass and find physical battles more difficult than their more biologically advanced peers. Competing against early maturing teams exacerbated this issue: "…he finds training and games really tough, physically, he just can't get around the pitch, he can't cope" (Coach 7). Coaches perceived later maturing players struggled to impact games (See Case Study Two and Four).

> *"…biologically he is behind and if you play [certain] teams they tend to play their biggest and strongest up front and then he is at the back and struggling" (Coach 1)*

As previously discussed, there are numerous reasons for coaches perceiving fewer positive contributions to games from later maturing players; late maturing players are smaller and less physical,[2] cover less distance and at lower intensities,[13,44,60] and are less likely to play in

dominant positions.[4] It is, thus, not surprising that coaches perceive later maturing players to have less impact.

Bio-banding is a strategy which could be used to increase opportunities for late maturing players to impact games. Bio-banding allows late maturing players to showcase their talent by limiting physical discrepancies and allowing them to play in more central positions.[4,28,30,31] Abbott and colleagues found late maturing boys participate in significantly more tackles and significantly less long passes in bio-banded games than in chronological age-group games; perhaps late maturing players are more willing to engage in tackling when competitors are of a similar size, and the advantages behind long ball passes to more mature teammates are removed.[29] Thus, academies should utilise bio-banding as a strategy to allow late maturing players to command games; this not only benefits the development of the player but also allows coaches to better evaluate players before selection decisions by being able to observe certain attributes within a different developmental context.[4]

Finally, coaches described the importance of the intentions of later maturing players. Coaches sensed many late maturing players had game intelligence, (i.e., understood the correct move or pass to complete) however, they lacked the physical capacity or confidence to follow these actions through (See Case Study Two). Potentially, late maturing players understand they lack the physical capacity to create certain passes or plays within a game, and thus choose to play a different tactic rather than make mistakes for example. Coaches of current senior international players who were late maturing in their youth, such as Kevin De Bruyne and Thibaut Courtois, recall their excellent understanding and decision making despite not having the physicality to compete.[61] Game intelligence and maturity status requires further investigation.

[TABLE 2(LM) HERE]

[Case Study Two here]

3: Differential Performance Expectations by Maturity Status

Coaches portrayed different expectations of their players depending upon maturity status. Across the age-groups, coaches had superior expectations of the more biologically mature: "The early's are critiqued harsher, yeah maybe it goes back to expectations, they (expectations) are higher" (Coach 6) and "some of the early maturing boys at times I can expect too much" (Coach 5) (See Case Study Three). Players advanced in maturity who excel in their own age-group and can compete or thrive in the age-group above were portrayed as "exceptional".

> *"Physically, early maturer, has played up in both the age-group above and the one above that this year, which is a fantastic achievement. Played well yeah, consistent you know" (Coach 3; player- 94.2% PAH, performance grade 2.67).*

Early maturing players were expected to impact games and perform well in their own age-group. Those not considered capable of playing up were perceived to be struggling:

> *"…really struggled, consistently been one of the weaker performers, tended to only play well really when he plays in [own age-group] game, which considering he is early maturer is a worry" (Coach 5).*

Further, early maturing players who were played in older age-group games were expected to perform:

> *"I am worried about him, he has been top boy in younger age-groups, and he's played up for me probably about four or five times and looked very average" (Coach 1; player- growth velocity 8.94cm/year, 91.3% PAH, performance grade 2.69).*

When early maturing players participate in bio-banded games, the level of physical and technical challenge is greater in comparison to chronological age-groups;[28,30] Coach expectations, however, appear to remain the same, where early maturing players are expected to perform well in both chronological and bio-banded groups. Although bio-banding can be used as an evaluation tool to ensure early maturing players are not being identified and invested in because of their advanced physicality,[4] there appears to be greater pressure on early maturing players to consistently perform. It is important to remember however, advanced maturity status is only one aspect of talent evaluation; for example, early maturing players may be experiencing growth or even problems off the field (school/home). The quote above, for instance, describes one player experiencing a high growth velocity (PHV).[4] Early maturing boys playing with chronologically older players in bio-banded games are also exposed to new developmental opportunities and challenges; early maturing players when bio-banded can learn to cope with vulnerability, adversity, and anxiety.[62]

Conversely, late maturing players who were managing in their own age-group were perceived as excellent: "…he is an alien, he is late maturing but physically one of the best in the group" (Coach 1; player- growth velocity 13.04cm/year, 87.6% PAH, performance grade 2.93). Players who were delayed in maturity who managed to succeed in their own age-group and compete in the age-group above, where the gap in maturity was even greater were described

by a coach as "freaks" as they surpass the expectations placed upon them. These players were perceived to be able to compete with boys they "shouldn't be able to".

> *"A player that is later within the group he doesn't really look it, I think he manages it well, a positive when you are dealing with late maturers that are coping in a category one academy in their own age-group, it is impressive" (Coach 5).*

Coaches described an expectation that late maturing athletes playing down an age-group should perform well, and coaches worried about players who did not: "Again playing down this weekend should be a breeze for him. He should be top two in the group" (Coach 2).

> *"That hasn't had any effect on him, his performances haven't, it's not like (age-group below) coaches have come back and said his performance was very good, he ran the game" (Coach 8).*

Bio-banding was often described as an evaluation tool because it creates competitive equity, where players can be assessed against biologically similar players. Bio-banding is useful as a talent identification and evaluation strategy; however, this is not the only use.[4,30] Bio-banding creates unique learning and development opportunities for players on either end of the maturity spectrum.[4,29,62] The bio-banding strategy should not preclude the consideration of psychological and or technical skills.[4] Thus, for late maturing players who are described to be thriving in their own age-group, playing down an age-group with boys of similar maturity may not be beneficial.[4] Similarly, coaches should not expect late maturing players to be 'the best in the group' when moving them to a chronologically younger group. For example, late maturing players may be experiencing challenges associated with the adolescent growth spurt.[46] Moreover, bio-banding presents an opportunity for late maturers to take on positions of leadership and show self-efficacy on the pitch.[62] Playing down an age-group may also advance other attributes such as leadership and mentoring skills.[62] Academies and coaches should acknowledge bio-banding has benefits other than talent evaluation, and perhaps reduce the pressure placed upon both early and late maturing players to succeed in bio-banded matches. Education around the merits of bio-banding could change the measure of success for coaches from 'outplaying' their peers to the development of other attributes.

Coaches described biases stemming from these differing expectations: "I have got to be careful of a bias…. I expect more of [Early] than I do of [Late], I expect him to play better" (Coach 5) and "I've got bias, and my bias is always for the underdog, so I want the underdog to do well someone like [late maturer]" (Coach 2).

This bias was discussed in terms of coaching, performance grades and selection decisions. Coaches expressed they "…could have been better" with their coaching of some early maturing boys and the system needs to support all athletes irrespective of their stage of development.

> *"I think I could have actually been better with him, he is a massively early maturer, and I think there is an element of me that has got, yeah there is a bias maybe slightly… I sometimes start to think that these players that are closer to 100% (PAH) are done, yet cognitively I know that's not the case, they are still a particular age, low training age, so I have probably been quite hard on him" (Coach 5; player- 99.5% PAH).*

In terms of performance grades, one coach discussed a late and early maturer delivering the same performance but the late maturer receiving a higher performance grade as the expectations upon that player were lower:

> *"If [early] has a slight off game he goes down to a 2, and that is going to affect his performance grade and his audit score. If [late] had exactly the same performance that [early] just had I would give him a 4, because my bias is clearly going on and I am thinking I cannot believe he has just managed to do all that as a late maturer, but an early I just expect it, so there is a bias" (Coach 5; player- Early=98.5% PAH, Late=93.3% PAH).*

An increasing number of articles discuss an over-representation of early maturing athletes in football.[22,25,26] Consistently, research has shown early maturing footballers tend to outperform their later maturing peers.[11,1317,22,23,53,60] Thus, a great deal of the headlines and strategies have been focused upon decreasing the selection bias against late maturing players.[3,23,25,26,63] Coaches in this study recognised their improvements in managing and developing late maturing players but also believed the development and education around late maturing athletes was at the expense of the development of their early maturing players. Youth sporting systems and programmes need to ensure athletes from both sides of the maturity spectrum are on the best programme for their maturity status and development.

[TABLE 3 HERE]

4: Implications for Selection, Retention and Release

Aligned with the advantages and disadvantages associated with early and late maturation, maturity status and timing had implications for the selection, retention, and release of decisions. Early maturing players were often described as the best players in the team and were regularly

selected over their late maturing teammates, because of their advanced physicality, game impact and performance consistency:

> *"He is a relatively early maturing player and probably done the majority of his growing, so hence probably ties in with the element of consistency in his performances and things" (Coach 6).*
>
> *"Probably the best keeper, but physically he is bigger than all of the others as well, so I think whether he is the best, it is more of his physical presence, his maturity, you know you compare him to [Late Maturer] who is the same age, I would say [Late Maturer] is half the size, you know a lot smaller" [Coach 3] (Selected early maturing player= 92.9% PAH, height =178cm, weight=80.7kg, growth velocity of 5.21cm/year, compared to released later maturing player=89.7% PAH, height= 162.3cm, weight=46.6kg, growth velocity of 6.55cm/year).*

Conversely, some early maturing players were released, or their scholarship was deliberated because of their technical/tactical deficiencies (See Case Study Three).

> *"Let go due to technical ability they didn't see that he had pushed on enough, obviously liked him physically but didn't feel like his technical ability was good enough for next level" (Coach 5).*

Zuber et al found precociously developed players, even with technical and psychological deficiencies, showed the most promise to be retained.[50] Importantly, in both this study and Zuber and colleague's investigation, not all technically deficient early maturing players were retained, highlighting advanced maturation alone is not enough to be retained.[50] Coaches recognised however, early maturing players had an easier journey through the academy because of their advanced size and physicality.

In contrast, late maturing players were awarded scholarships for their excellent technical ability and their unexpected physical ability. For most late maturing players, coaches described them as physically behind; Late maturing players who were also physically developed were identified as likely to be signed and given scholarship: "He is a bit of an anomaly, because he is late but physically one of the best in the group" (Coach 2) and *"*Alien. Late maturing but physically of the best in the group. He is the best in the academy in my opinion...offered an early scholarship" (Coach 1).

As described previously, coaches generally felt later maturing athletes impacted games less because of their lack of physicality. Coaches described a need for patience with late maturing boys, waiting for them to physically catch up. The deadline for making scholarship and selection decisions confounded coaches' patience, however.

> *"At the moment because of the lack of physicality he is really finding it quite difficult. We have got to overlook that, we can't make decisions based on physicality at the moment" (Coach 3- player was released).*

For many late maturing players, their lack of physicality was a factor in their release, however.

> *"He has played about a quarter of his games in the [age-group below] because he is a low bio-banded because he is a late maturer. He has got some ability, physically however, since he has been here, it has been a struggle physically. Lack of pace, lack of turn, lack of agility, you can still see that in the age-group below as well, absolutely… I just think this is the wrong environment for him" (Coach 3- Player was released).*

Coaches perceived it was harder to get late maturing players "over the line" with scholarships: "without question it is harder to get a later maturer over the line for a scholar, especially when you get people coming in that make decisions that haven't seen much of them" (Coach 5). One coach explained why it was harder for late maturing players to be signed at under 16.

> *"It must be so tough for those boys like, experiencing growth in those age-groups at that time, bigger football, bigger pitches, all those things that demand you to be bigger, you're then playing against teams who are generally early and then we critique and grade them, sometimes the expectations are too high" (Coach 6).*

This finding aligns with Mitchell and colleague's suggestion, that a disadvantage of late maturation is that athletes experience the growth spurt when the load, intensity, and pressure upon them is greatest.[36]

Late maturing players who were impacting games and managing to compete in their own age-group, coaches described as probable scholars and exciting prospects. Coaches described some late maturing players as synonymous with potential; Players further away from being mature had more still to come, and so were retained or scholared based on their potential:

> *"I think considering how late he is, I think his energy levels and his mobility to keep running and willingness to keep running forward and back, doesn't faze him that he is up against someone bigger, he will try and use what physicality he has got, and he is quick, I bet he has so much to come, I think there is a lot there" (Coach 7).*

Coaches perceived many late maturing players to be less capable of achieving success at the next level and, thus, less likely to be retained or offered scholarships. Delayed maturation can be compensated for through a high level of technical, tactical, and psychological ability in the younger age-groups.[50] At the older age-groups however, even highly skilled achievement-

orientated late maturing players fail to progress to the next level.[50] Thus, for late maturing athletes to be succeed, they must not only display exceptional technical, psychological and tactical skills, but also be physically capable; the quote above, where a late maturing player is described as an 'alien' shows the retainment and scholarship of a late maturing player as rare.

Many late maturing athletes, who do not reach these exceptional levels are released from academies. The quotes above illustrate the notion that coaches often see potential in their later maturing athletes, but the timing of scholarship decisions means there is a greater risk in offering places to late maturing athletes (See Case Study Four). Coaches struggle to differentiate between a lack of ability or a lack of physical development due to late maturity; in selection decisions, there are more unknowns for later than early maturing players. However, there are some exceptional famous cases, where talented late maturing athletes have been retained and scholared yet played down an age-group until they developed.[64] Although logistically challenging, signing late maturing athletes and allowing them time to develop in a chronologically younger age-group could be supporting late maturing players.

[Case Study Three here]

[Case Study Four here]

This study explored coaches' perceptions, experiences, and management of their team of adolescent academy football players, where naturally the athletes vary in stages of biological maturation. This study utilised a mixed-methods approach to explore 'how' and 'why' maturity selection biases exist within elite academy football. Only one professional football academy was utilised in this study and therefore results may not be generalisable to other academies with different philosophies, values and practices. Further, this research only focused upon the male game; future research should explore this in the female game. Additional research across more talent environments is necessary to substantiate these findings.

Conclusion:

Individual differences in biological maturation presents academy players and their coaches with numerous challenges. Coaches perceived that maturing both ahead (early) and in delay of (late) peers had advantages and disadvantages for current performance and development. Early maturing players were described as bigger, and thus, generally more athletic, and capable of consistently performing at the expected academy standard. Coaches believed early maturing players often relied on their advanced size and physicality to compete, and therefore neglected

development of other skills. Late maturing players were generally described to be smaller and often struggled to compete against their more precocious peers, but coaches explained their potential was deemed to be high, due to their advanced skill development (technical, tactical and psychological) and further growth still to come. Interventions such as bio-banding to mitigate these issues and change perceptions of athletes were described. These maturity differences within the same age-group caused coaches to have different performance expectations of players. In turn, this had implications for talent identification and selection decisions. Individual differences in biological maturation in one age-group appears to influence perceptions of performance and potential, player development, and talent identification and selection.

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Table 1: Further supporting quotes of the subtheme 'early maturation'

Sub Theme	Evidence:
Early Maturation	*Very early maturer, has got some good strong physical attributes because of that in terms of his size, physicality, his range of passes is quite varied because he has the strength to make those much longer passes (Coach 3; player- 94.2% PAH, performance grade 2.75).*
	I think I am right in saying he is an early one, he is powerful, he is quick, we haven't seen anything on the eye, not much change in the last year from him, as in speed, fitness, endurance, I think he has been that size for a while now…we haven't seen him getting more powerful, quicker, getting through games better…if anything he is struggling, I think he reached his peak back end of last season, hence why we haven't seen a shift in anything from him (Coach 8; player-growth velocity of 0cm/year, 99.7% PAH, performance grade 2.09).
	The early's see have to then work on their technical attributes, and body positioning, awareness, to combat being an early developer (Coach 7).
	He is someone who has got their way through the system by being a bit of a big kid, and not had to think about his game, or how long he spends on the ball, or whether he has to track runners properly because he can just deal with it and catch up (Coach 1; player-growth velocity of 6.70cm/year, 92.5% PAH, performance grade 2.63).
	He is very early isn't he, I believe he is early, again physically he is very powerful, very quick, very strong, don't think he uses his body well enough at times which is quite interesting, in terms of how he uses it to protect the ball, to win the ball, in those types of situations, even though he is an early he seems to struggle with the ball being played in behind him, he can get caught out sometimes, little bit naïve maybe because of where he has come from, and his background, best player in grass roots football, and got away with a lot of things, now he is being exposed for things like that... Could use his physical attributes to his advantages at times (Coach 6; player- growth velocity of 1.92cm/year, 95.4% PAH, performance grade 2.14).
	You can only rely on it for a certain amount of time, before ultimately the weaknesses start to open up and show because you haven't worked on them (Coach 8).

Table 2: Further supporting quotes of the subtheme 'late maturation'.

Sub Theme	Evidence
Late Maturation	*Awareness, simple as that, awareness, can he work something out, does he not get into that physical battle because if you have got all that you have got understanding and game intelligence so as you get older and you start to grow, you have already got the basics, the fundamentals, the knowledge to get away from that, and as when you become physical if you want to deal with it you can, but you have also got the other bits….I don't care about the physical stuff, I want to see a football brightness or a football intelligence (Coach 8).*
	…he is quite a slight lad… he struggles with 1v1 and I think that's where he has adapted his game to you know, anticipate and read the game and intercept it rather than trying to going in for the physical battle (Coach 3; player- growth velocity of 5.96cm/year, 91.5% PAH, 2nd latest maturer in team, performance grade 2.91).
	He has shown some good intentions in terms of his passing, sometimes he hesitates, takes additional touches, because I think he lacks confidence in his ability to strike the ball, and because of his lack of range (Coach 6).
	His biggest problem is wanting to go long, because he can't kick a ball properly, so he doesn't want to try it, he just hasn't got the capacity to do it, I don't know whether he doesn't want to do it, or he is scared because he knows he can't do it so he just won't try to do it (Coach 9).

Table 3: Further supporting quotes of the subtheme 'differential performance expectations by maturity status'.

Sub Theme	Evidence
Differential Performance Expectations by Maturity Status	*Early maturer that is probably struggling so yeah a double negative…he is a concern because he is probably bottom third of the group and he should be able to play up and it wouldn't even be considered, but for an early maturing player, poor testing scores, average performances, should be looking to strive to play up and probably doesn't (Coach 1; player- growth velocity 9.68cm/year, 90.1% PAH, performance grade 2.47).*
	Has played up and done quite well when he has gone up, you're starting to see quite a few deficiencies in his game which have naturally happened because he has been early and athletic, so we were trying to work on that and his footwork and his defending is off, his balance, he can just bundle people out of the way so we are really careful at the moment that when he comes back he will need to be in with the 16's quite quickly, I think if he stays in with this group those deficiencies won't go away. A lot of people suggesting early scholar, I am probably not as convinced at the moment if I am honest, I think he has got more to do, I think he is now slightly getting caught physically and I'm seeing some deficiencies in his game (Coach 5; player- growth velocity of 1.92cm/year, 95.4% PAH, performance grade 2.14).
	I think we still need to hang on to him and be patient and just wait and see what we see, he moves well, he looks agile, he gets around the goal, his feet are good, and he is still quite little, and when he plays [in age group below] he still looks, he even looks like [age group below], we would see bigger goalkeepers in our age group so think he is playing with [own age-group] is unusual. He has done alright when playing with us [age group below]. I think he has the most potential and it would be a shame to make an early judgement on him because I think he needs more time (Coach 1-Player was released).
	He for me is an absolute shoo in for scholar, but there has been a little bit of uncertainty at times, and interesting, I was talking to (age-group above coach) about the chances of (Cup game) and the first thing he said was it's a real shame we haven't got [Late maturing player] and I said how come and he said because he'd have helped us go through, and I thought, because they are a bit unsure, and I thought if you believe that about a late maturer then he should be a shoo in scholarship…everyone is seeing him have an impact on games still, even though he is late, which for me if you have those types of players, they need to be scholars as they don't come around very often. Late and impacting still you know (Coach 5) (Late maturer who was retained and scholared-Growth velocity of 1.4cm/year, 94.9% PAH, performance grade 2.8).

Case Study One: The Bulldozer.

This case study depicts multiple coaches' evaluations of one early maturing 13-year-old player over two time points, who is perceived to rely on his advanced size and physicality. Some text is bolded for further emphasis. See supplementary file 3 for further discussion.

Time Frame:	**May-September**	**October- January**
Quantitative Data	91.9% PAH Growth Velocity of 9.33cm/year Performance Grade 2.89 Coach 1 and 2	94.2% PAH Growth Velocity of 11.23cm/year Performance Grade 2.46 Coach 1,2, 3 and 4
Coaches Comments	Is early, could be **super early**. Good thing about him is he scores goals, and consistently scores different types of goals. He **relies a lot on power and holding up the ball and overpowering his opponent** and last year he could do that when he played up. So, when he is put in his bio-banded group he doesn't, **he struggles to adapt** his game to know what to do. **It is whether what he is doing now, he will be able to do in the end**. Not very quick, but a bright player, he wants to get better and wants the challenge, but he has had lots of success throughout the age-groups, I just wonder when he gets to 16, I think he is going to be average size, maybe quite stocky, but [another late maturer] will be a better athlete than him so they are nicely matched up, when they get to 16 I think [another late maturer] will win those battles. **Extremely confident,** he is quite a **good all-round player**, but I have some concerns because his natural way, he can just do it, if he played up would he become a different kind of striker. He **should probably play up all the time**, but it is a jigsaw.... But if it was all about him that is what you would do, you would play him up the whole season. If you judge him on potential, I think he is lower, I think the audit is interesting because he was given an A, but I don't think his potential is that. I think at 16 or 17 he will be an ok player.	Coach 1 and 2: **Super early**, he hasn't been with us recently, we requested him to play in the 14's because you know in our age-group it is a bit of a false reading of his potential, because he is so early, so we pushed quite hard for him to go up and fortunately he is now... If we sit down with him and talk about performance, we can say yes you are **scoring goals, and impacting games but he is playing in the wrong age-group**. He was getting tastes of playing up in the 14's playing out of position or playing limited time, so we just needed to do it for a period where were actually sure what we are looking at… He always trains well, he just needs to do that an age-group up, because the way he plays in the 13's is a **big strong powerful target player** but actually when you put him in the 14's he is not that big, he can handle himself but he is not going to be a problem for a 14 year old defender. So, it is just **future proofing him** of whether he is going to be that type of player, or whether he is going to play further back… so it's just protecting what he is going to look like in the future. Coach 3 and 4: he is playing up with us you see, another one that has **relied so heavily on his size** that he has picked up a **few little bad habits** particularly with his movement you know, he always wants the ball to feet because **he knows he can turn the player**, and now that he is having trouble doing that we are saying there's no point having it to feet all the time because they are bigger and stronger than you so what are you going to do. This is going to benefit him but I think he should go back go to his own group now though because he has been with us a little while and I think he is starting to suffer a little bit with a lack of confidence because he is not having the success and he is a striker, so we need to keep his self-belief up.

Case Study Two: The Underdog

This case study depicts the coach's perceptions over three phases of one 14/15-year-old later maturing player. This player was described as being physically behind his teammates, however, was technically and tactically ahead of his peers. See supplementary file 3 for further discussion.

Time Frame	**Jan-April**	**May-September**	**October- January**
Quantitative Data	91% PAH, Growth Velocity of 9.31cm/year Performance Grade 2.33 Coach 3 and 4	93.2% PAH, Growth Velocity of 10.70cm/year Performance Grade 2.13 Coach 5 and 6	94% PAH, Growth Velocity of 7.49cm/year Performance Grade 2.46 Coach 5 and 6

Coaches Comment	**Steady** player, he is probably a 6 out of 10 in games and in training. Really good feet in terms of ball manipulation, but probably over does it, probably takes too many touches, impact of that is he then tends to get caught on the ball… We certainly can see some qualities there which is why he has been retained but without being too harsh probably **needs to be more consistent**…he has got the ability to make decent passes. Generally shorter ones he is quiet a pass and move type of player, so we do need to increase his range… Tough year for him, last year on a smaller pitch, he was more effective, like **he can't get close to people**, the **big pitch** really, I mean **people just knock him out of the way** he **can't really affect the game as much**, his first touch has been a little bit off. He has got bit very big feet for a young boy and for his size. Late maturer, catches his feet when he is walking on the floor, like they are that big and bless him it has been quiet a tough one for him, but we see he has **got potential still**. The physical side is a good point, later maturer going on a big pitch, size 5 football. You know in that central role as well, can be quite demanding physically so stamina wise he is very good, he **can run forever, but when it gets to the contact part he struggles a little bit.** He gets over there and then suddenly in one movement all that hard work of getting over there is just gone, but luckily we really are quite educated here so at least we can see it. He is **beating himself up about it**.	Quite obviously that he is a **later maturer** within the group, just physically in general, **smaller** than everyone else, you can also see in terms of opposite of [EM]…he **sees things and tries to execute it but doesn't have the range of pass in him**, quite important for us to understand this is where maturation plays a huge part in understanding that it is the intention that is the right thing, but actually expecting them to complete it can come later. He has done really well, he has **shown some good intentions** in terms of his passing, sometimes **he hesitates, takes additional touches, because I think he lacks confidence** in his ability to strike the ball, and because of his **lack of range**, but his understanding of the position he plays in is above anybody in the age group… **Movement to receive is exceptional, even the little things, awareness of the ball, body shape, all those things he needs for his position are exceptional**. It is just connecting the range of passes…Sometimes **struggles to cover the ground** I think. He has struggled a lot in previous seasons, but I quite like him, **good mover, clever player, gets into good positions**, probably in terms of the 4, **his understanding is probably ahead of [EM] even though EM performs better or is more effective in games**... He gives it a really good go, gets into great positions, help us play, when we lose the ball you know that he is **not going to be able to cover the ground**, so **ultimately the team does suffer from that**. In terms of **potential** I do think there is something there.	Performances have probably been relatively consistent which is unusual, because of his age, and the fact he is later maturing… you would expect him being inconsistent in his performances but I would say apart from last week it's been the opposite of that. He has gone **down with the 14s and not stood out,** and the stats in the last game he played, he gave the ball away double the amount of any other player, lost possession of the ball, you could look at like he has gone down and probably used it as an opportunity to try things which could be a reflection of how confident he is you know, performing well in the 15's, been given an opportunity to drop down and play with players of similar physical age and seen it as an opportunity to be experimental and take risks… Will turn down some passes if they don't think they are able to do it or don't have the range so you can see that they can see the pass but they choose not to play the pass which they do find themselves in trouble in losing the ball. **Not confident** in their contact with the ball... still probably some issues around how much he can cover the ground, I mean he is **clearly late** but I also think he is not going to be a fantastic mover anyway. He seems to be more aggressive; he is positioning himself better, you **can see the tactical element of his game**, he seems to be more confident…you just **hope when we get to 16's that people can see he is late because I know that is a question that keeps coming up from a lot of people about how much he impacts the game**.

Case Study Three: The Falling Star

This case study represents coaches' perceptions of two early maturing players over the first and last study period (Jan- Aril and Oct-Jan). Quantitative and qualitative data present context of the player within the team and their growth velocity, game time and maturity status. This case study illustrates early maturing players who were released at the end of the season. See supplementary file 3 for further discussion.

Phase 1: Jan-April:

Coach 5: Erm again, this is an early maturer that I have questioned whether there is a bias there because I know his physical attributes that he has now, are not going to be that much further clear of other players as he gets older, so he has really struggled as technically he is quite a way off as well. Probably the lowest in the group at the moment…really struggled, he really struggled, consistently been one of the weaker performers, tended to only play well really when he plays down one or two age-groups, which considering he is an early maturer is a worry…I was worried he would get caught physically. And then the other things that he maybe he hasn't built up over the years, hasn't been challenged, I think we are now probably seeing that if I am honest.

Game time in this period: 8 games, 550 minutes
Played all games in Bio-half 1 (most mature in team) with an average match grade of 2.13
Growth velocity in this period= 1.49cm/year
Percentage of Predicted adult height in January= 99%

Phase 3: Oct-Jan:

Coach 7: He is another one, just an early developer, his attributes probably as an under 15 have got him through to a certain point, again now, players are becoming quicker, not just physically but brain wise as well, players have gone past him, he tries to still rely on the attributes that got him here like his size, but ultimately he is not big is he now, he is done, he was probably that size at 13 or 14, and he has plateaued, there is no more growth in him, his shoulders are done, his cheekbones are done.

Coach 8: I might be wrong but I think, I have a feeling, at 13 when he signed and he would have impressed because of all the things you just said, he would have been an early back then I would imagine, whereas now I think he sits in the middle of the group, but he relies on what he had when he was 13, and it just doesn't happen, there is no cleverness to his footwork or to his game, I think he will get wider, but there is no more height. I think he just hasn't had to use it before, he has relied on physicality and so he has never had to use a technical quality or have a good understanding of when and where to move, which is why he doesn't have it now, the game is too quick for him now

Case Study Three continued: The Falling Star

Coach 7: you can only rely on it for a certain amount of time, before ultimately the weaknesses start to open up and show because you haven't worked on them, or not had access to that point to build that gap because they get bigger and bigger as the older you get and the age-groups you go in.

Coach 8: and the technique I am not sure we can put it down to a growth thing, I'm not sure you could do that, I have seen some people like go a bit wobbly, because he's shot up quickly and he is kicking the floor more often than not, but I saw a technique before, whereas I am not seeing any sort of improvement or technique from him.

Growth Velocity=3.65cm/year

Performance Grade=2.00

Case Study 4: Released Late Maturer

This Case study is an example of a late maturing player who was released. Three coaches over two time periods (Jan-April and May-Oct) share their perceptions of this late maturing player. Quantitative data shows where within the team this player was positioned in terms of maturity, growth velocity and performance grade. This Case Study shows the different opinions surrounding the same player in the run up to a selection decision. See supplementary file 3 for further discussion.

Growth Velocity in this Period: 8.19cm/year

%PAH in January= 92%; %PAH in April=93.3%

Played all games in Bio-half 2 (least mature) with an average match grade of 2.29

Coach 5:

Really interesting one, now this is purely on the eye, because I have not seen this, but it just seems like everyone else is going through theirs or have gone through theirs, but he just still looks like a 13-year-old. He has lovely balance, lovely player technically but I would look at where most people are at the start of the season and for him the physical changes don't seem to have been that big, like others, and people are starting to pull away, he just seems to have been quite steadily really late, and it clearly has impacted his performances and his impact on the game.

My view, ok I gave him a B in the audit, I think he will get a scholar, but in order for that to happen, and all the talk is going that way, is that we will need to be very patient.

So I think with, he should be fine, and I think it will be one that we call here, one wild card, I am not sure it needs to be called that yeah I think he will get that but it does worry me because a beautiful footballer, balance, technique, you know he's going to be physical… he has got the traits, but it's just mad if he had gone through his growth spurt early you would probably again be talking about an early scholar, yet he goes through it late and he is going to have to go right up to the wire.

He is good, he is good physically, but he is not at that level so the gap between him and an early is so much greater. Throw into that the position he has largely been played in this season, he is in the 10 for most of this season, which is notoriously going to have big 4's and centre backs around you… Goalkeepers are massively early, centre backs massive early, 9's massive early, at least one of the midfielders if not 2 are massive and early. So that is who you are up against, we don't do it that way, we try and put you in a position we think you're going to end up in so for him its likely it could be a 10, so he has been in there and that's just what he is up against.

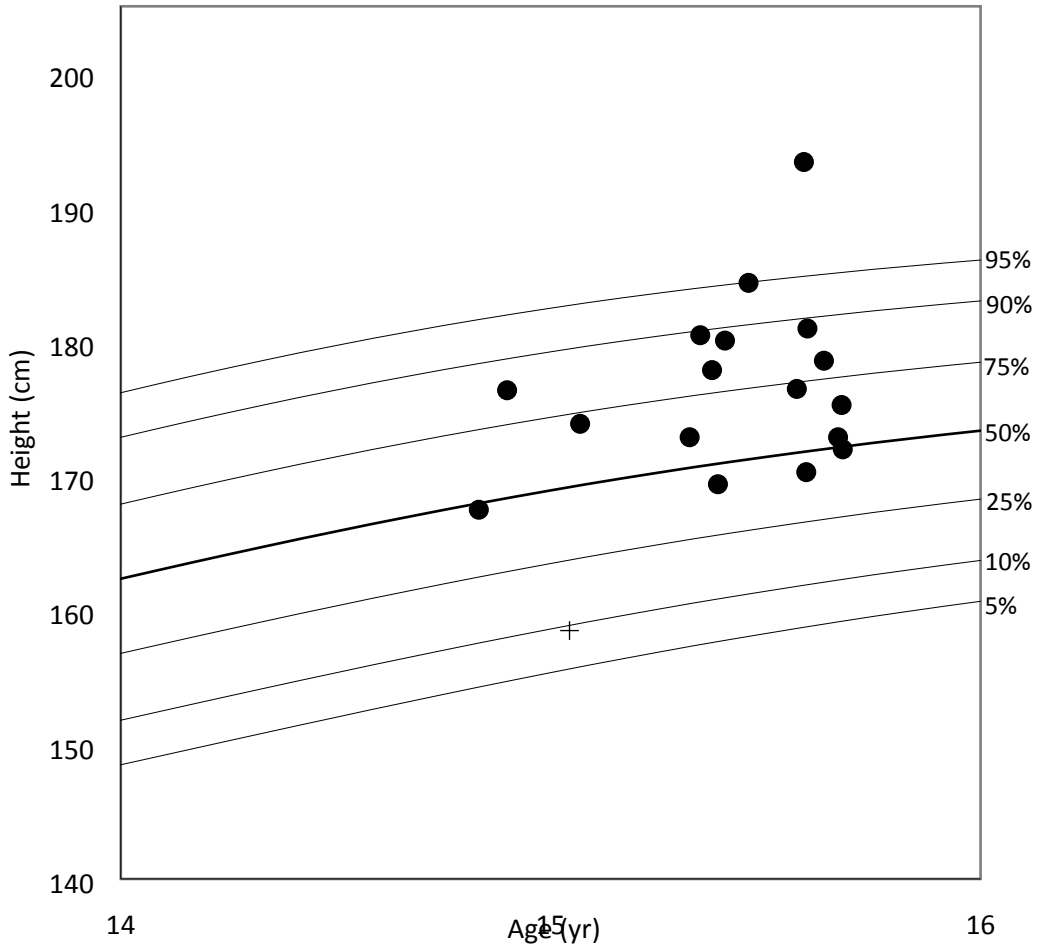


Figure: UK Growth Charts depicting the distribution of the players' heights relative to age, with the case example from case study seven highlighted in red.

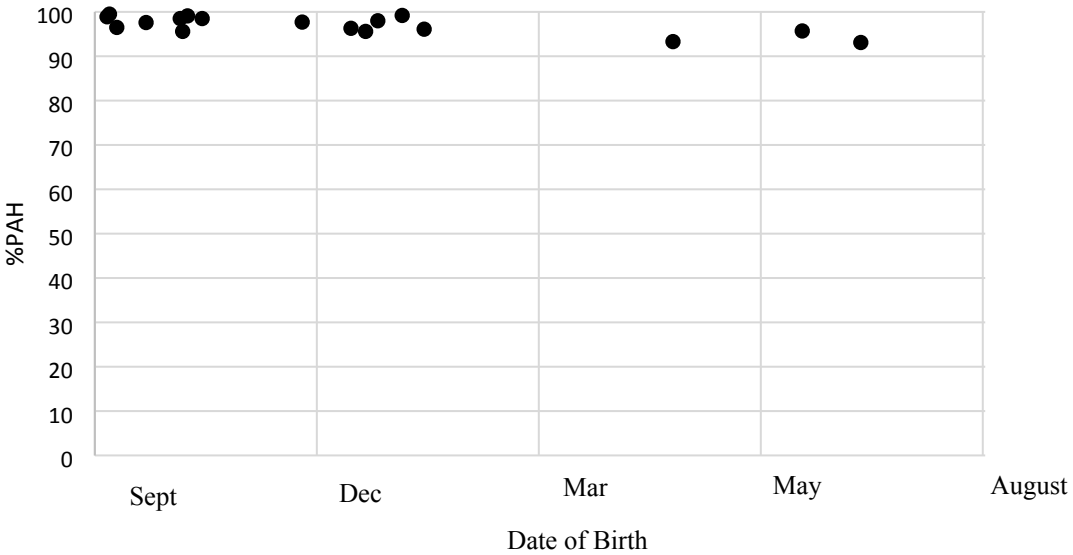


Figure: Graph depicting players' percentage of predicted adult height relative to their chronological age within the group with case example from case study four highlighted in red.

Case Study four continued: Released Late Maturer:

New Season: May-Released in November.

Growth Velocity in this Period: 4.81cm/year

%PAH in November= 95.1%

Played all games in Bio-half 2 (least mature) with an average match grade of 1.82.

Coach 5: It was obvious he was late, that was discussed, we probably felt he could go further than other people felt…Just so late, in the year we have seen him, I don't think we have seen much growth.

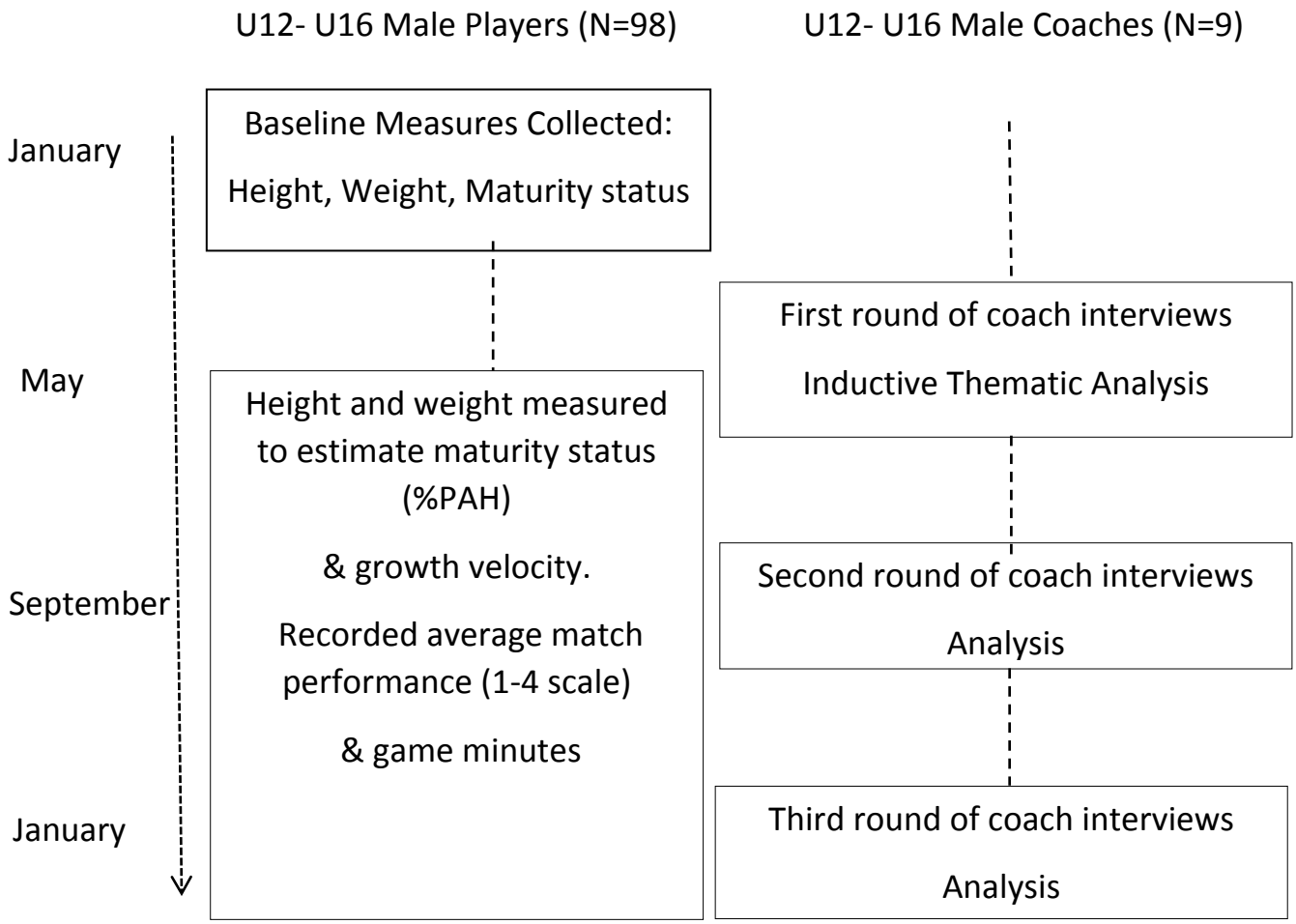
Coach 8: I think you have to be careful, I think he is late, but I think, I don't think much more will come from his dynamics, I can't see him having an extra kick, he is a plodder, everything is just below three quarters he hasn't got a change in speed or a turn or acceleration, and that's just him, I don't think that will come, regardless of where he is in his growth and maturity, I think that's him done.

Coach 7: he finds training and games really tough, physically, he just can't get around the pitch, he can't cope, erm, but on the very flip of it when you look into the minute details of it, he doesn't do himself any favours with how he controls the ball or where he puts it, he creates fights because of bug heavy touches and things, where I would like to see him be like [another late maturing player] and work it out more, and adapt he doesn't.

Coach 8: go and fight the battles you can win by being not marked, he doesn't. sounds simple doesn't it.

Interviewer: do you play him down an age-group?

Coach 8: he has yeah he has, but that hasn't had any effect on him, his performances haven't, it's not like 15's coaches have come back and said his performance was very good, he ran the game, whereas [another late maturer] can play up for us, and physically can't recover and get forward as much, but stands in good areas and does well.



Supplementary Figure 1: Procedures followed for data collection.

Supplementary Table 1: Descriptive statistics for percentage of predicted adult height (PPAH) over time by age group (%)

Age Group	Sample size (n)	January-April			May-September			October-January		
		$\bar{x}$	SD	range	$\bar{x}$	SD	range	$\bar{x}$	SD	range
Under 12	16	87.40	2.69	8.6	88.35	2.71	9.1	90.14	2.72	9.0
Under 13	22	88.48	1.58	6.7	89.53	1.63	6.8	91.06	2.07	5.6
Under 14	15	93.53	1.59	4.7	95.04	1.39	3.8	95.84	1.49	4.3
Under 15	18	97.02	1.96	6.4	97.71	1.71	6.3	98.45	1.44	4.8

$\bar{x}$ = mean, SD= standard deviation

Supplementary File 3:

Case Study:	Further Evidence:
Case Study One: The Bulldozer	*This case study provides data on one early maturing 13-year-old player, across two time points, with four coaches providing contextualised data. At the second phase (October-January), the boy was more mature, remained in a period of high growth, and their performance grade was poorer than the previous time point (May-September).* *In time point one, the coaches described the player to be super early maturing and to use their advanced physicality to score goals and impact games. When this player was playing in more physically matched groupings (bio-banded) they struggled to adapt their game. The coaches were therefore sceptical as to whether this player would be able to play in the same style when other players matured.* *At the second phase, largely, the same concerns remained. This player had developed bad habits when playing with and against players who were biologically younger and struggled to. The player continued to be one of the most mature in the group and to ensure the player continued to develop their skills, the coaches moved the player into an older age-group to challenge them. The coaches believed the increased level of challenge and decrease in success in an older age group led to a decrease in the player's confidence.* *This case study provides an example of an early maturing player, using their advanced physicality to compete, and their respective coaches concerned about their future potential when other players eventually caught up. In this case study, coaches created a more challenging environment for this player, by moving them into an older age category, to 'future proof' the player; by positioning them in an environment where they cannot use their advanced physicality and they must therefore develop and learn other skills. Although this was perceived to benefit the player, it was also deemed to affect confidence. Bio-banding or moving early maturing players into older age categories therefore needs to be considerate of psychosocial factors. Coaches should educate the players as to the purpose of bio-banding, and players could benefit from further psychological support.*
Case Study Two: The Underdog	*This case study involves data from one late maturing 14/15-year-old player across a 12-month period. Over time the player becomes more mature, has a growth velocity consistently higher than the childhood rates of growth (5-6cm), and coaches performance grades dip in the second time point, before increasing again in the third phase to the highest grade at 2.46.* *In time point one, the coaches described the player to be 'steady', with some qualities in terms of technical skills, however performances were perceived to be inconsistent. Coaches noted that the player struggled to impact games due to being a later maturing player, and this was affecting his confidence. In time point two, coaches continued to praise this player's technical abilities, and this player's struggles due to their maturity status; coaches believed this player had the knowledge to make the correct game decisions, however lacked the ability to carry these actions out due to his size and strength. The coaches praised the player's technical abilities and believed the player did have potential despite current performances. In time point 3, this player experienced playing in the age group below, a group more physically matched to reduce the level of challenge, however coaches believed the player had not thrived in this new environment. One coach considered that the player had used this opportunity to be more creative and try new skills in a setting where the physical challenge had been produced. Coaches still considered this player to have potential, however wondered other talent*

	selectors would be able to appreciate this. *This case study shows bio-banding, or moving later maturing players into younger age groups, can be used to allow later maturing players to play in a less physically challenging environment which in turn allows them to play with more freedom than in their chronological grouping. This case study also highlights the hurdles late maturing players face within a competitive football academy. The caches believed this player had excellent technical and tactical skills, and therefore had great potential, however there were still reservations within the academy as to whether this player would receive a scholarship due to his little impact on the game. Talent selectors need to be educated on the impact of maturation upon performance, and potentially sporting governing bodies need to consider growth and maturation when creating selection policies.*
Case Study Three: The Falling Star	*The falling star case study describes two different early maturing players who at the end of the season were released. The coaches described the early maturing players and perceived there to be no further growth or development. Further, the coaches perceived the players to have survived in the academy system thus far because of their advanced maturity status and they had relied upon these attributes at the neglect of other skills. Later maturing peers were now physically catching up to these players but had acquired a more advanced technical and tactical skillset to outshine these players who were successful in the younger age groups.* *This case study highlights the need for young early maturing players to develop their skillset and not solely rely on their advanced size. Academies and coaches need to ensure they are challenging their early maturing players to promote their skill development to ensure they do not become technically and tactically deficient. Constrained practices and bio-banding could be possible solutions to increase the challenge for early maturing athletes.*
Case Study Four: Released Late Maturer	*The final case study represents a late maturing player over two time points who was later released. Across the two time points, this athlete played all games as one of the later maturing players within the team, and his performance match grade was poorer (1.82) in the second time point.* *At time point one, coaches described this player to be extremely late maturing with good technical attributes. This player was described to have potential but needed to remain patient in order to get a scholarship, and even then, coaches were not confident that this player would impress enough talent selectors.* *At time point two, coaches described this player to struggle in games and training because of his delayed maturity status, in addition to some poor technical skills. When played in a lower chronological age group, this player remained one of the later maturing players, but did not impress coaches enough when played down. Coaches believed this player had reached his potential and believed there would be no further development in his skillset. This player was later released.* *The quantitative data shows this player was extremely late maturing, and coaches provided context to show this player struggled with the physicality of the game despite being technically proficient. This case study provides an example of the difficulties in retaining late maturing athletes, and perhaps explains the under representation of late maturing players within academies. Due to the high pressured competitive environment, often, late maturing players are not afforded the time to catch up physically with their peers. They may therefore be released before appreciating their true potential.*